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The Analysis of Dimensional Changes and The Number of Simple Composite Girder Dimoro Bridge On The Southern Coast Access In Malang East Java

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Abstract- Accelerated development of cross-coastal access to southern eastern Java, known as the South Coast Cross Lane (JLS) very dependent with the topography of the southern region of Java island, about 65% of JLS are in mountainous and coastal areas. One of them is the construction of Dimoro Bridge in Malang East Java region with simple composite girder type spans 20.00 meters. According to basic design, girder dimensions use IWF. 980 x 350 x 10 x 35, with the number of girder n = 7 and the girder length 20.40 m. The issue of girder dimensions IWF. 980 x 350 x 10 x 35 is not mass-produced by the steel industry, so there needs to be a design review with the dimensions of girder in the steel industry market with IWF. 800 x 300 x 14 x 26. The analysis of dimensional changes and the number of simple composite girder is reviewed from : (1) the height of the girder profile approaching plan (d), because when the smallest (d) value is taken there will be more number of girder (n) installed. (2) the weight of the bridge structural steel approaching plan (Wr), since if Wr' < Wr means fulfilled by not changing the calculation of the bridge foundation, if Wr' > Wr then it is necessary to recalculate the strength of the bridge foundation. Analyze results for bending moments on IWF girder. 800 x 300 x 14 x 26 is obtained : M pre-composite = 43850 kg.cm, M post-composite = 13816200 kg.cm. The moment of resistance (wb) due to Mpre and Mpost = 5003 cm3. Moment of inertia (Ix) = 282554 cm4 (table Ix = 292000 cm4). The moment of resistance (wx) = 7064 cm3 (table wx = 7290 cm3). Control of ultimate stress σau* = 2780 kg/cm2 is obtained Mmax = 12030000 kg.cm, σa' = Mmax/wx = 2405 kg/cm2 > σa = 1850 kg/cm2, the stress σa' exceeds the permit stress σa but still below ultimate stress σau* (safe). Control of deflection, for L/250 obtained Ix = 157733 cm4 < Ix plan = 282554 cm4 (safe). For L/360 obtained Ix = 201819 cm4 < Ix plan = 282554 cm4 (safe). Control of the shear stress obtained T = 229.76 kg.cm2 <T'= 0.58xσa = 0.58 x 1850 = 1073 kg.cm2 (safe). Control of tensile stress and press on composite girder, compressive stress σsu = 389.7 kg/cm2 < σa = 1850 kg/cm2 (safe), tensile stress σsl = 1123.3 kg/cm2 < σa = 1850 kg/cm2 (safe). Preferred on the composite girder is the compressive stress (σsu), and the resulting compressive stress (σsu) after the composite is smaller than the allowable stress (σa = 1850 kg/cm2; σau* = 2780 kg/cm2), the dimensional change IWF girder being 800 x 300 x 14 x 26 is safe to use. The change of girder number to IWF 800 x 300 x 14 x 26, profile area F = 261 cm2 (table F = 267 cm2), girder weight per m wt1 = 261x0.785 = 205.00 kg/m' (table = 210.00 kg/m'), weight 1 girder Wt(p) = 4100 kg. Needs of girder n'= Wt7/Wt(p) = 9.40 → taken 9 girder, Wt9 = 36900 kg < Wt plan = 38556 kg (ok). Accessories on the composite girder include : connection plate + bolt, diaphragm (bracing iron elbow) + bolt, shear-connector. Total weight of Accessories 9 girder = (3692+215+737) = 4644 kg. Total weight of composite bridge steel structure 9 girder Wr = 36900+4644 = 41544 kg < weight plan Wr = 41635 kg (fulfilled by not changing bridge foundation calculation).

Keywords: *pre-composite moment, post-composite moment, ultimate stress, deflection, shear stress.*

1. Introduction

Currently the prosperity of fishing communities on the south coast of East Java depending on the construction of road and bridge access. Accelerated development of cross-coastal access to southern eastern Java, known as the South Coast Cross Lane (JLS) very dependent with the topography of the southern region of Java island, about 65% of JLS are in mountainous and coastal areas. Consequently, not all locations can be built roads with arterial function. Therefore, road and bridge infrastructure is a major requirement on the South Coast Cross Lane. One of them is the construction of Dimoro Bridge in Malang East Java region with simple composite girder type spans 20.00 meters.

In a bridge planning (basic design) should be considered for the use of easy-to-do and easy to transport material. Currently most of the southern coastal locations have no access roads and bridges. Therefore, the construction of road access and the selection of bridge types and construction costs are the main priorities for the implementation of the work to be quickly completed, low in construction costs and safe in the construction structure.

The initial concept, the bridge using the T beam type, then revised into a simple composite beam type. For technical reasons, the duration of the in-situ casting system of the T beam is longer compared to steel girder profile manufacturing. According to basic design, girder dimensions use IWF. 980 x 350 x 10 x 35, with the number of girder n=7 and the girder length 20.40 m. If following the PU Bina Marga standard for span 19.40 m composite girder it can use the H-Beam girder dimension 500 x 300 x 9 x 19, with the number of girder n=8 and the girder length 20.00 m.

Problems in the field, girder dimensions IWF. 980 x 350 x 10 x 35 is not mass-produced by the steel industry, so there needs to be a design review with the dimensions of girder in the steel industry market with IWF. 800 x 300 x 14 x 26.

2. Literature Review

Bridges are structures that need to be well planned in order to function optimally. Simple composite beam bridge is a bridge type beam from IWF steel profile with a simple support system and capable of carrying bridge deck-plate loads and vehicle loads. For the calculation of bridge loading following RSNI T-02-2005, while planning steel structure for bridge follow RSNI T-03-2005.

3. Technical Review

Technical studies taken based on the basic design approach method, that is the strength of replacement composite beams at least have the same strength with the composite beam plan in basic design. Dimensional changes and number of simple composite girder will be reviewed from : (1) the height of the girder profile approaching plan (d), because when the smallest (d) value is taken there will be more number of girder (n) installed. (2) the weight of the bridge structural steel approaching plan (Wr), since if Wr' < Wr means fulfilled by not changing the calculation of the bridge foundation, if Wr' > Wr then it is necessary to recalculate the strength of the bridge foundation.

4. Stages of Calculation

Try to review the design only on the upper structure of the bridge, which is limited only to the composite girder and not to recalculate the strength of the bridge foundation. The first to be re-planned is the change in the dimensions of the IWF steel beam profile. By first looking for bending moments on deck-slab and bending moments on the beam with pre-composite loading and post-composite loading. Checking moments of inertia and resisting moment on IWF beams. Then controls the maximum moment, control of deflection, control of shear stress on the composite beam. The second one that will be re-planned is the change in the number of girder. By first looking for the total weight of the plan girder, and the total weight of the change girder. Looking for heavy girder accessories ie connection plate + bolt, diaphragm (bracing iron elbow) + bolt, and shear-connector. Then control of the steel weight of the bridge structure approaching plan (Wr).

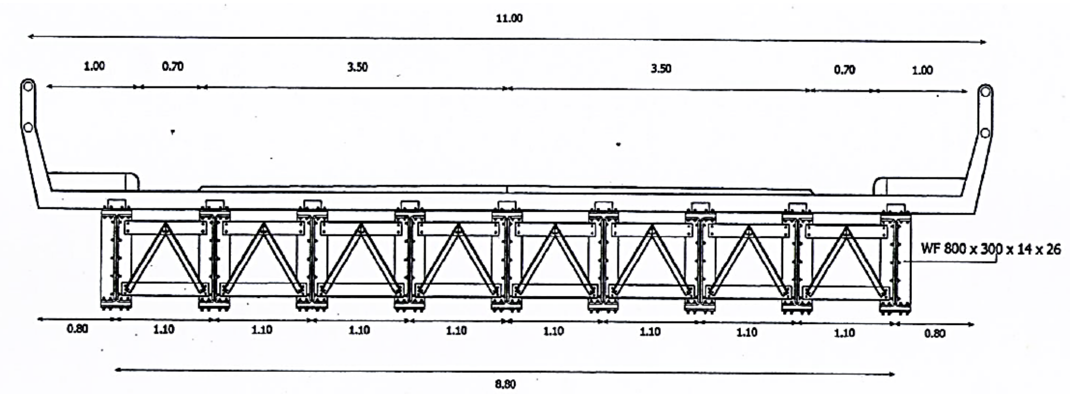

Fig.1. Typical simple composite girder bridge

The following is a simple composite beam bridge data:

Dimension beam (basic-design) :

Bridge span : 20.00 meters
Beam length : 20.40 meters
Steel beam structure : IWF. 980x350x10x35, n = 7 beams
Distance beam : 1.60 meters
Configuration of the beam: (0.40 m + 7 beams @ 1.60 m + 0.40 m)

Beam Dimensions (Changes):

Bridge span : 19.60 meters
Beam length : 20.00 meters
Steel beam structure : IWF. 800x300x14x26, n = 9 beams
Beam distance : 1.10 meters
Configuration of the beam: (0.80 m + 9 beam @ 1.10 m + 0.80 m)
Concrete Quality : K-350 (fc' = Kx0.83/10 = 29,05 Mpa)
Steel Quality : U-32
Asphalt width : 7.00 m (thick 0.10 m)
Sidewalk width : 1.00 m (thick 0.20 m)
Floor bridge width : 10.40 m (thick 0.20 m)
Abutment width : 11.00 m

5. Analysis and Results

5.1. Bending Moment (Mu) on slab

Loading : q1 deck-slab = q floor plates + q asphalt + q rainwater = (0.20 x 2500) + (0.10 x 2200) + (0.05 x 1000) = 770 kg/m. q2 sidewalk = q sidewalk + q rainwater + q load use = (0.20 x 2500) + (0.05 x 1000) + 500 = 1050 kg/m. Railing from pipe + concrete pile, assumed as full wall : P1 = 1.25 x (0.16 + 0.25)/2 x 2500 = 641 kg/m. Axle Load Truck (Load T) P2 = 10 ton. Truck wheel load distribution (T load) : Sa = ¾ a + ¾ r.Lx, where r = ⅔ → Sa = 0.715 m < 1.50 m.

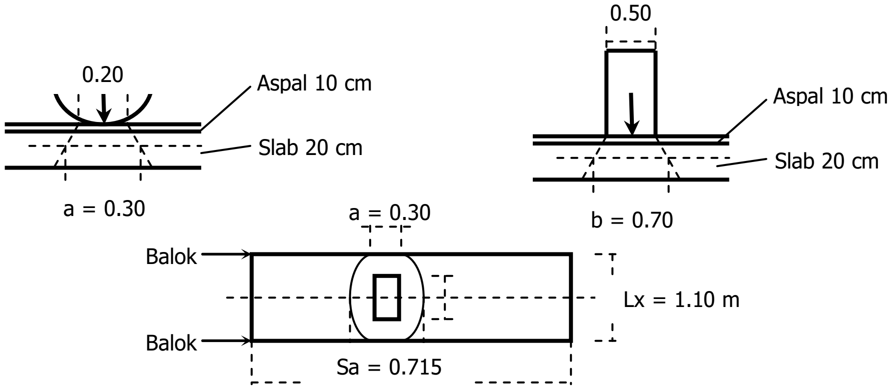

Fig.2. Tru istribution (T load)

5.1.1. Bending moment due to T Load P2 and q1 above deck-slab
5.1.1.1. Bending Moment due to Load P2 :

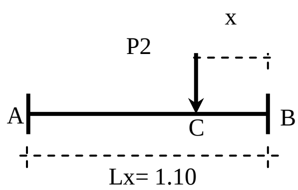

Fig.3. Bending moment deck-slab between the two beams

End beam moment ($M_{\mathbf{A}}$) :
$M_{\mathbf{A}} = -(P.a^2.b) / L^2 = -P.x^2.(L-x) / L^2$
$M_{\mathbf{B}} = -(P.a.b^2) / L^2 = -P.x.(L-x)^2 / L^2$
Moment maximum ($M_{\mathbf{A}}$), when $M_{\mathbf{A}} = 0$
$M_{\mathbf{A}} = -1/L^2 .(P.L.x - P.x^3)$
$0 = -2.L + 3.x$
$x = 2/3.L \rightarrow M_{\mathbf{A}} = -(P.x^2.(L-x) / L^2$
$M_{\mathbf{A}} = -4/9.P.L + 8/27.P.L = 4/27.P.L$
$M_{\mathbf{A}} = 4/27.\ 10\ .\ 1.10 = 1629.63$ kg.m
width a = 0.30 m, then moment at point A :
$M'_{\mathbf{A}} = 1629.63 / 0.30 = 5432.10$ kg.m. → Mu2 = 5432.10 kg.m.

Field moment or middle beam moment ($M_{\mathbf{C}}$) :
$M_{\mathbf{C}} = P.x.(L-x) / L + M_{\mathbf{A}}.x / L + M_{\mathbf{B}}.(L-x) / L$
$0 = P.x.(L-x).L^2 / L^3 + P.x^2.(L-x).x / L^3 - P.x.(L-x)^3 / L^3$
$0 = L^2 + x^2 - (L-x)^2$
$0 = 2.L.x$
$X = ½.L \rightarrow$ used : $M_{\mathbf{C}} = 1/8.P.L = 1/8.10.(1.10) = 1375$ kg.m
width Sa = 0.715 m, then moment at point C :
$M'_{\mathbf{C}} = 1375 / 0.715 = 1923.08$ kg.m. → Mu3 = 1923.08 kg.m.

5.1.1.2. Bending Moment due to Load q1:

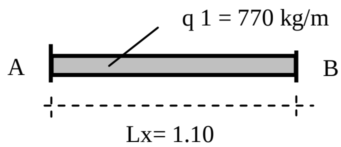

Fig. 4. Bending Moment due to Load q1

M end beam (Mu2) = $1/12.q1.L^2$ = 77.64 kg.m ; M field (Mu3) = $1/8.q1.L^2$ = 116.46 kg.m.

5.1.2. Bending moment due to P1 and q2 above sidewalk-slab

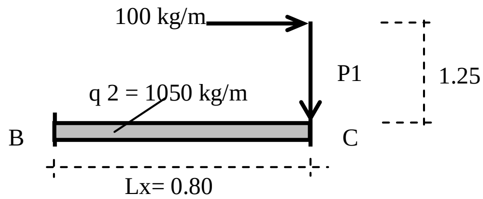

Fig.5. Bending Moment due to Load P1 and q2

Mu1 = ½. q2 . L^2 + P1. 1.25 + 100. 1.25 = 1262.25 kg.m.

Total moment (SF = 1.5) for floor plate reinforcement (slab) :
- Moment cantilever beam (Mu1) = 1262.25 x 1.5 = 1893.38 kg.m
- Moment end beam (Mu2) = (5432.10 + 77.64) x 1.5 = 8264.61 kg.m
- Moment field (Mu3) = (1923.08 + 116.46) x 1.5= 3059.31 kg.m

For reinforcement of floor plates bridge used the above three moments, according to Ultimate Method of SNI.

5.2. Moment maximum on beam IWF. 800 x 300 x 14 x 26

Assumptions : weight 1 beam IWF. 800 x 300 x 14 x 26 (length 20.00 m) = 4100.00 kg, weight 1 beam IWF + beam accessories = (4100 + 516) = 4616.00 kg, weight beam per 1.00 m (4616 kg/20.00 m = 230.80 kg/m) = 231 kg/m, weight floor plates per 1.00 m (0.20+0.27)/2 x 1.10 x 2500 = 646 kg/m → Load q1 = 877 kg/m.

5.2.1. Loading composite beam

Load q2 = q asphalt + q rainwater + q load use = (0.10 x 1.10 x 2200) + (0.05 x 1.10 x 1000) + 100 = 397 kg/m. Line load (P) = 12 ton → P = 12/2.75 x 1.10 = 4800.00 kg. Distributed load (P') = 2.2 t/m (Ly < 30.00 m), Ly = 20.00 m → P'= 2.2/2.75 x 1.10 = 880.00 kg. Shock load : K= 1 + 20/(50+Ly) = 1.286 → P = 1.286 x 4800 = 6172.80 kg and P'= 1.286 x 880 = 1131.68 kg/m

5.2.1.1. Bending moment on beam (pre-composite and post-composite):

M pre = 1/8. q1 . Ly^2 = 1/8. 877. 20^2 = 43850 kg.cm.

M post = 1/8. q2. Ly^2 + ½.P.Ly + 1/8.P'. Ly^2 = 1/8.(397).20^2 + ½.(6172.80).20 + 1/8. (1131.68).20^2 = 138162 kg.m ~ 13816200 kg.cm.

5.2.1.2. Resistance moment (wb) due to M pre and M post:

On the composite beam the resistance moment (wbc) range from 1.5 - 2.5 times wb, then taken wbc = 1.5 wb. U-32 steel quality has σau = 3200 kg/cm^2, σa = 1850 kg/cm^2 (0.58.σau), σau*= 2780 kg/cm^2 (0.87.σau). Looking for resistance moment with σa = Mpre / w_b + Mpost / w_{bc} → 1850 = 43850/$w_{\mathbf{b}}$ + 13816200/(1.5.$w_{\mathbf{b}}$) → $w_{\mathbf{b}}$ = (43850 + 9210800)/1850 = 5003 cm^3. Resistance moment (wb) due to M pre and M post : $w_{\mathbf{b}}$ = 5003 cm^3.

With availability of IWF profile in the steel industry market, that is IWF. 800 x 300 x 14 x 26 with high beam (d) to 80.0 cm (initially high beam (d) to 98.0 cm). Then the IWF. 800 x 300 x 14 x 26 is still to be controlled against stresses that occur and resistance moment that occur (resistance moment is also called opponent moment or static moment), where resistance moment that occurs (wb) must be less than the planning resistance moment (wx) of IWF profile used.

5.3. Moment of inertia and moment of resistance IWF. 800 x 300 x 14 x 26

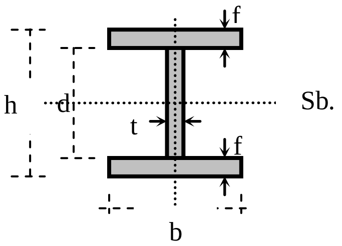

Fig.6. Dimensional steel beam profile IWF

Profile area F = b.h – d.(b-t) cm^2
Distance axis y_0 = b/2 cm
Moments of inertia I_x = 1/12.{b.h^3-d^3.(b-t)} cm^4
Moments of resistance w_x = 1/6h.{b.h^3-d^3.(b-t)} cm^3

Dimensional steel beam profile IWF :
h = 80.0 cm
d = 74.8 cm h/t = 80.0 / 1.4 = 57.14 < 75 (ok)
b = 30 cm L/h = 2000 / 80.0 = 25
t = 1.4 cm 1.25x(b/f) = 1.25x(30/2.6) = 14.42
f = 2.6 cm L/h to 1.25x(b/f) : 25 > 14.42 (ok)
F= b.h – d.(b-t) = 30x80 – 74.8(30-1.4) = 261 cm^2
I_x =1/12.{b.h^3-d^3.(b-t)}= 1/12.{30x80^3-74.8^3.(30-1.4)}= 282554 cm^4,
(table I_x= 292000 cm^4)
w_x =1/6h.{b.h^3-d^3.(b-t)}= 1/6h.{30x80^3-74.8^3.(30-1.4)}= 7064 cm^3,
(table w_x= 7290 cm^3)

5.3.1. Controls moment maximum :

pre composite q1= 877 kg/m.
post composite q2= 397 kg/m, P= 6172.80 kg, P'= 1131.68 kg/m.
qt = 877 + 397 + 1131.68 = 2406 kg/m.
M max = 1/8 .qt.L^2 = 1/8.(2406).20^2 = 120300 kg.m = 12030000 kg.cm.
σa' = $M_{max}/w_{\mathbf{x}}$ = 12030000 / 5003 = 2405 kg/cm^2 > σa = 1850 kg/cm^2 (exceeding the allowable stress but still below the ultimate stress σau* = 2780 kg/cm2) (ok).

5.3.2. Control of deflection

5.3.2.1. Control of deflection due to dead load

$E = 2.1 \times 10^6$; qt = q1+q2 = 877+397 = 1274 kg/m

f = L/250

f max = 5/384 . $(q.L^4)/(E.I_x)$, and I_x = 5/384 . $(q.L^4)/(E.f)$, then :

I_x = 5/384 . $(q.L^4)/(E.f)$ = 5/384 . $(q.L^4.250)/(E.L)$ = 5/384 . $(q.L^3.250)/E$

$I_x = 0.013 \times (12.74 \times (2000)^3 \times 250) / E$

I_x = 157733 cm^4 < $I_{x\ rencana}$ = 282554 cm^4, (table I_x = 292000 cm^4) (ok)

5.3.2.2. Control of deflection due to live load

$E = 2.1 \times 10^6$; q = P' = 1131.68 kg/m

f = L/360

f max = 5/384 . $(q.L^4)/(E.I_x)$, and I_x = 5/384 . $(q.L^4)/(E.f)$, then :

I_x = 5/384 . $(q.L^4)/(E.f)$ = 5/384 . $(q.L^4.360)/(E.L)$ = 5/384 . $(q.L^3.360)/E$

$I_x = 0.013 \times (11.32 \times (2000)^3 \times 360) / E$

I_x = 201819 cm^4 < $I_{x\ rencana}$ = 282554 cm^4, (table I_x = 292000 cm^4) (ok)

5.3.3. Control of shear stress

$D_{max} = R_A = R_A$ = ½. qt . L = ½. 2406. 20 = 24060 kg

$\tau = D_{max}$ / t.d = 24060 / 1.4 x 74.8 = 229.76 kg.cm^2

τ = 229.76 kg.cm^2 < τ' = 0.58.σa = 0.58 x 1850 = 1073 kg.cm^2 (ok)

5.4. Stresses on the composite beam

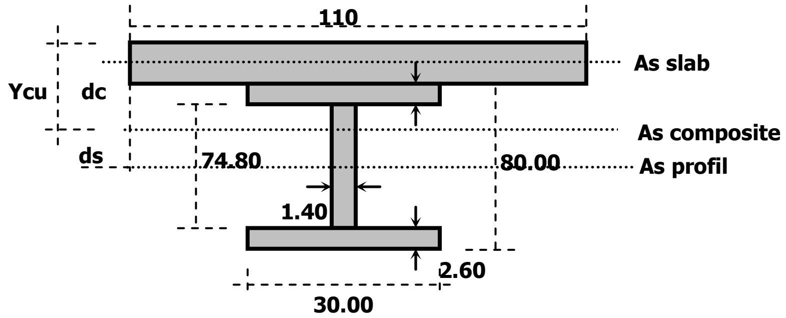

Fig.7. Stresses on the composite beam

M pre = 43850 kg.cm

M post = 138162 kg.m ~ 13816200 kg.cm

W_b = 5003 cm^3

I_x = 282554 cm^4, (tabLE I_x = 292000 cm^4)

5.4.1. Stress pre-composite

σsl = Mpre / w_b = 43850 / 5003 = 8.8 kg/cm^2 (tarik)

σsu = - 8.8 kg/cm^2 (tekan)

5.4.2. Stress post-composite

As steel = 261 cm^2, h = 80.0 cm

Ac concrete = 110 x 20 = 2200 cm^2

Ic = 1/12 x 110 x 20^3 = 73333 cm^4

$dc = (As.1/2h) / (As+Ac/n) = 10440 / 383.22 = 27.24$ cm
Concrete Quality K-350 (fc' = Kx0.83/10 = 29,05 Mpa) → $n = 330/ \sqrt{350} = 18$
$d = (d\ slab + d\ WF)/2 = (20+80)/2 = 50.00$ cm
$ds = d - dc = 50.00 - 27.24 = 22.76$ cm

5.4.3. Moments of inertia on the composite center line

$Iv = Ix + As.\ ds^2 + 1/n.\ (Ic + Ac.dc^2)$
$Iv = 282554 + 261\ .\ 22.76^2 + 1/18.\ (73333 + 2200.\ 27.24^2) = 512522\ cm^4$
$Ycu = - d\ slab/2 - dc = - 20/2 - 27.24 = - 37.24$ cm
$Ysu = d\ slab/2 - dc = 20/2 - 27.24 = - 17.24$ cm
$Ysl = (d\ slab/2+h) - dc = (20/2+80) - 27.24 = 62.76$ cm
$h = Ysu + Ysl = 17.24 + 62.76 = 80.00$ cm

$\sigma cu = (Mpost / Iv) \times Ycu \times 1/n$
$\sigma cu = (13816200 / 512522).(- 37.24).\ 1/18$
$\sigma cu = -34.28\ kg/cm^2$ (compressive) $< \sigma b' = 0.33\ \sigma bk = 0.33 \times 350 = 115\ kg/cm^2$ (ok)

$\sigma su = (Mpost / Iv) \times Ysu$
$\sigma su = (9501200 / 535077).(-14.75)$
$\sigma su = 380.9\ kg/cm^2$ (compressive)

$\sigma sl = (Mpost / Iv) \times Ysl$
$\sigma sl = (9501200 / 535077).(62.76)$
$\sigma sl = 1114.4\ kg/cm^2$ (tensile)

5.4.4. Total Stress

Compressive stress $\sigma su = 8.8+380.9 = 389.7\ kg/cm^2 < \sigma a = 1850\ kg/cm^2$ (ok).
Tensile stress $\sigma sl = 8.8+1114.4 = 1123.3\ kg/cm^2 < \sigma a = 1850\ kg/cm^2$ (ok).
The priority of composite girdes is compressive stress (σsu), and the resulting compressive stress (σsu) after composite is smaller than allowable stress (σa = 1850 kg/cm2; σau* = 2780 kg/cm2), so fulfilled the requirements then changes dimension beam IWF. 800 x 300 x 14 x 26 is safe to use.

5.5. The number of beams (n)

5.5.1. Beam plan with IWF. 980 x 350 x 10 x 35

Dimensions of the beam h = 98.0 cm, d = 91.0 cm, bf = 35.0 cm, t1 = 1.0 cm, t2 = 3.5 cm. Profile area (F) = 343 cm2. Profile weight 1.00 m2 (w) = 7850 kg/m2. Profile weight 1.00 cm2 (w) = 0.785 kg/cm2. Profile weight 1.00 m' (w') = 343 x 0.785 = 270.00 kg/m'. Weight beam 1 piece Wt (1) = 20.40 x 270.00 = 5508 kg. Total weight beam of 7 pieces Wt (7) = 5508 x 7 = 38556 kg (without beam accessories).

5.5.2. Beam changes with IWF. 800 x 300 x 14 x 26

Dimensions of the beam h = 80.0 cm, d = 74.8 cm, bf = 30.0 cm, t1 = 1.4 cm, t2 = 2.6 cm. Profile area (F) = 261 cm2 (table = 267 cm2). Profile weight 1.00 m2 (w) = 7850 kg/m2. Profile weight 1.00 cm2 (w) = 0.785 kg/cm2. Profile weight 1.00 m' (w') = 261 x 0.785 = 205.00 kg/m' (table = 210.00 kg/m'). Weight beam 1 piece Wt (p) = 20.00 x 205.00 = 4100 kg.

5.5.3. Number of beam (n) and spacing beam (bo)

Number of beam with IWF. 800 x 300 x 14 x 26 is (n) = Wt(7)/Wt(p) = 38556/4100 = 9.40 beam → taken 9 beams. Total beam distance no.1 to no.9 = 10.40 - 1.60 = 8.80 m. Spacing beam (bo) = 8.80/(n-1) = 1.10 m < (bo) plan with IWF. 980 x 350 x 10 x 35 = 1.60 m (ok) → taken (bo) = 1.10 m.

5.5.4. Weight of beam accessories

Beam accessories consist : connection plate with bolts, diaphragm (bracing iron elbow) with bolts, and shear-connector. Fabric manufacturing 1 girder length 20.00 m, there are 3 points of connection plate per beam, consisting of length 3 @ 6.00 m + 2.00 m. Using IWF. 800 x 300 x 14 x 26 (n) = 9 beams.

Calculation of weight of beam accessories (cast iron = 7250 kg/m2) :

Flens IWF : 0.70 x 0.30 x 2 x 0.02 x 3 x 9 x 7250 kg/m2	= 1644	kg
0.70 x 0.14 x 4 x 0.01 x 3 x 9 x 7250 kg/m2	= 767	kg
Bolts flens dia.25 : (24+24) x 3 x 9 x 0.15 kg/piece	= 194	kg
Web IWF : 0.66 x 0.40 x 2 x 0.01 x 3 x 9 x 7250 kg/m2	= 1033	kg
Bolts web dia.19 : (20) x 3 x 9 x 0.10 kg/piece	= 54	kg
The total weight of the connection plate (9 beam)	= 3692	kg
Diaphragm (bracing iron elbow) there are 5 points / blocks :		
L.150.75.11 : (1.00+0.70) x 2 x 5 x 9 x 0.897 kg/m	= 137	kg
L. 75.55.10 : (0.90) x 2 x 5 x 9 x 0.300 kg/m	= 24	kg
Bolts dia.19 : (12) x 5 x 9 x 0.10 kg/piece	= 54	kg
The total weight of the diaphragm (9 beam)	= 215	kg

Shear-connector D.16 :

Number of shear-connector (n) = 70 piece/beam, length 0.75 m/piece.

The total weight of shear-connector = 9 x 70 x 0.75 x 1.560 kg/m = 737 kg.

The total weight of accessories 9 beam = (3692 + 215 + 737) = 4644 kg.

The total weight of accessories 1 beam = 4644 / 9 = 516 kg.

5.5.5. Total weight of steel structures 1 bridge

For accessories beam plan IWF. 980 x 350 x 10 x 35 (from the list of weight beam plan) = 7 x 440 kg = 3079 kg, so the total weight of the plan beam Wr(7) = 38556 + 3079 = 41635 kg. While weight of IWF. 800 x 300 x 14 x 26 (n) = 9 beams (without beam accessories) is Wt (9) = 4100 x 9 = 36900 kg < Wt (7) beam plan = 38556 kg (fulfilled 96%). Difference total weight of beam plan : (38556 - 36900) = 1656.00 kg. For weight of accessories 9 beams = 4644 kg. Control total weight of steel structure for 1 bridge 9 beams : Wr'(9) = 36900 + 4644 = 41544 kg < weight plan Wr(7) = 41635 kg (fulfilled 99.8% ok). So Wr '<Wr means does not change the calculation of bridge pile foundation.

6. Conclusion

The number of beams increases from 7 beams to 9 beams, it must be controlled by stresses and moment of resistance that occurs in profile IWF. 800 x 300 x 14 x 26. Moment of resistance which occurs (wb = 5003 cm^3) shall be less than the planning resistance moment (wx = 7064 cm^3) of IWF profile used. Priority of composite girdes is compressive stress (σsu), resulting compressive stress (σsu) after composite is must be smaller than allowable stress (σa = 1850 kg/cm2; σau* = 2780 kg/cm2), and stated changes dimension beam IWF. 800 x 300 x 14 x 26 is safe to use. Control total weight of steel structure for 1 bridge, should be Wr '<Wr means fulfilled with the intention of not changing the calculation of bridge pile foundation). If Wr '> Wr then it is necessary to recalculate the strength of the bridge pile foundation.

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